TITLE

METHOD OF NETWORK ADDRESS PORT TRANSLATION AND

GATEWAY USING THE SAME

BACKGROUND OF THE INVENTION

5 **Field of the Invention**

The present invention relates to a gateway, and
in particular to a network address port translation
(NAPT) gateway providing fast look-up and translation
of network addresses and ports in virtual servers.

10 **Description of the Related Art**

Fig. 1 is a schematic diagram of a NAPT gateway.
Fig. 2 is a schematic diagram of a method for
translation in a conventional NAPT gateway, in which a
virtual internal network contains servers 120 and 122

15 of which private (virtual) internet protocol (IP)
addresses are S1 and S2 respectively. The external
network comprises hosts 100, 102, and 104, public IP
addresses of which are C1, C2 and C3 respectively.
The hosts 100, 102, and 104 set up a connection to the

20 NAPT gateway 110 device using ports CP1, CP2, and CP3.
The public IP address of the NAPT gateway 110 is
address G. The NAPT gateway 110 has a virtual server
mapping table 112 recording GP1, SP1 corresponding to
GP1, GP2, and SP2 corresponding to GP2.

25 When external host 100, 102, or 104 transports
data packets to ports GP1 or GP2 of NAPT gateway 110,
the NAPT gateway 110 performs NAPT, transports the
data packets to port SP1 of the internal server 120 or

port SP2 of the internal server 122, and records the translation data in NAPT table 114 for translation of returned outgoing data packets of the same connection from the internal servers.

5   The translation data recording port CP1 of host 100, port GP1 of NAPT gateway 110, and port SP1 of internal server 120 are recorded in the NAPT translation table 114, as shown in Fig. 2. The host 100 transports a data packet 130 to the NAPT gateway 110, which contains source IP address, source port, destination IP address and destination port. The source IP address and the source port are IP address C1 and port CP1 of the host 100. The destination IP address and port are IP address G and port GP1 of NAPT gateway 110, wherein the port GP1 corresponds to port SP1 of the server 120. When receiving data packet 130, the NAPT gateway 110 searches the translation data in the NAPT translation table 114 by hashing or linear searching. When the translation data is located, the data packet 130 is translated into data packet 132 destination IP address and port of which are IP address S1 and port SP1 of server 120.

In reverse direction, server 120 transports a data packet 134 to the external host 100. The data packet 134 contains source IP address S1, source port SP1, destination IP address C1 and destination port CP1. When receiving data packet 134, the NAPT gateway 110 also searches the translation data in the NAPT translation table 114 by hashing or linear searching. When the translation data is located, the data packet

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134 is translated into data packet 136 source IP address and port of which are public IP address G and port GP1 of the NAPT gateway 110.

Linear search of the translation data in the NAPT translation table 114 is extremely time-consuming, and hashing can cause collision, in the event of which, rehashing or linear searching can solve the collision. Even so, if a hash function is not chosen properly, time spent on hashing will be as much as that spent on linear searching.

SUMMARY OF THE INVENTION

Accordingly, an object of the invention is to provide a method of fast look-up and translation of network addresses and ports in a NAPT gateway. When a data packet is transported from an internal server to an external host through the NAPT gateway, the destination address or port information therein can be directly mapped to translation data corresponding to the data packet in the NAPT translation table without hashing or linear searching.

To achieve the foregoing object, the invention provides a method of fast look-up and translation of network address and port, performed in a gateway connecting a virtual internal network and an external network. The virtual internal network comprises at least a server, and the external network includes at least a host. First, a translation table is created, comprising a plurality of translation data entries each of which is provided with an index and comprises

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host address and port information, server address and port information, and gateway address and port information. The server address and port information further comprises internet protocol (IP) address

5   information and port information. Next, a first data packet containing first source address and port information and first destination address and port information from the external host is received by the gateway. The first source address and port

10 information comprises IP address information and port information. Corresponding translation data of the first data packet in the translation table is searched. The first source IP address or port information is translated into a factor related to the

15 index of the translation data and the first destination address and port information are translated into the server IP address and port information of the corresponding translation data when the corresponding translation data of the first data

20 packet is located. The first data packet is transported to a corresponding internal server according to the server IP address information therein.

In addition, a second data packet comprising

25 second source address and port information and second destination address and port information from the internal server is received by the gateway. The second destination address and port information comprises second destination IP address and port

information, one of which acts as a second factor related to a second index according to the system design. The related second index is acquired according to the second factor and corresponding translation

5 data of the second data packet is **got** from the translation table according to the second index **directly**. Next, the second source address and port information are translated into gateway address and port information of the translation data, and the

10 second destination IP address or port information are translated into host IP address or port information of the translation data. The second data packet is transported to a corresponding external host according to the IP address thereof.

15 In addition, the invention provides a network address port translation (NAPT) and fast look-up gateway connecting a virtual network and an external network, comprising a translation table, a receiving unit, a processing unit and a transporting unit. The

20 translation table comprises a plurality of translation data entries each provided with an index and comprising host address and port information, server address and port information, and gateway address and port information. The server address and port

25 information comprises internet protocol (IP) address and port information. The receiving unit receives, from the external host, a first data packet comprising first source address and port information and first destination address and port information. The first

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source address and port information comprises first IP

address and port information. The processing unit

searches corresponding translation data of the first

data packet in the translation table and translates

5   the first source IP address or port information into a

factor related to the index of the translation data

and the first destination address and port information

into the internal server address and port information

of the corresponding translation data when the

10   corresponding translation data of the first data

packet is located. The transporting unit is coupled

with the processing unit and transports the first data

packet to a corresponding server according to the

server IP address therein.

15   In addition, the receiving unit receives, from

the internal server, a second data packet containing

second source address and port information and second

destination address and port information. The second

destination address and port information contains

20   second IP address and port information, one of which

acts as a second factor related to a second index

according to the system design. The processing unit

acquires the related second index according to the

second factor, **retrieves** corresponding translation

25   data of the second data packet from the translation

table according to the second index **directly** and

translates the second source address and port

information into gateway address and port information

of the translation data and the second destination IP

30   address or port information into host IP address or

port information of the translation data according to the system design. Finally, the transporting unit transports the second data packet to a corresponding external host according to the IP address of the

5 corresponding host.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention can be more fully understood by reading the subsequent detailed description and examples with references made to the

10 accompanying drawings, wherein:

Fig. 1 is a schematic diagram of a conventional NAPT gateway.

Fig. 2 is a schematic diagram of the NAPT method for a conventional NAPT gateway.

15 Fig. 3 is a structural diagram of the NAPT gateway according to the first embodiment of the present invention.

Fig. 4 is a schematic diagram of the method of network address port translation and fast look-up in

20 the first embodiment of the invention.

Fig. 5 is the structural diagram of the NAPT gateway of the second embodiment of the invention.

Fig. 6 is a schematic diagram of the method of network address port translation and fast look-up in

25 the second embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

As summarized above, the present invention provides a method of fast look-up and translation of network address and port performed in a NAPT gateway.

Fig. 3 is a structural diagram of the NAPT gateway according to the first embodiment of the present invention.

The NAPT gateway 310 connects a virtual internal network and an external network. In this embodiment, the virtual internal network containing server 320 and 322 private IP addresses of which are S1 and S2 and providing service on port SP1 and SP2 respectively. As well, the external network contains hosts 300, 302, and 304 legal public IP addresses of which are C1, C2 and C3 and connecting to a NAPT gateway 310 device using port CP1, CP2, and CP3 respectively. The NAPT gateway 310 is provided with a legal public address G, and comprises a virtual server mapping table 312. The virtual server mapping table 312 stores a plurality of mapping data entries each comprising server address and port information containing a private IP address and port information of a server and corresponding gateway address and port information containing a gateway IP address and gateway port information, wherein gateway IP address is a public IP address of the gateway 310, and gateway port information is a corresponding port of the port of the server where service is provided. In this embodiment, two sets of mapping data are stored in virtual server mapping table 312: [G, GP1, S1, SP1] and [G, GP2, S2, SP2], representing that port GP1 and GP2 of NAPT gateway 310 mapped to port SP1 of server 320 and port SP2 of server 322.

As well, a NAPT translation table 314 is maintained in NAPT gateway 310. NAPT gateway 310 provides each set of translation data with an index. Each set of translation data comprises host address

5   and port information, server address and port information, and gateway address and port information, wherein host address and port information comprises a host IP address and host port information, server address and port information comprises private server

10   IP address and port information, and gateway address and port information comprises gateway IP address and gateway port information. The gateway IP address comprises the legal public address of the NAPT gateway, and the gateway port information comprises a

15   port number of the NAPT gateway corresponding to the port of a server where service is provided. The NAPT gateway 310 further comprises a processing unit 316 controlling network address look up and translation.

Fig. 4 shows a schematic diagram of the method of

20   fast look up and translation of network address and port in this embodiment of the invention. The host 300 in the external network transports a data packet 330 from port CP1 to port GP1 of NAPT gateway 310. The data packet 330 includes source IP address, source

25   port information, destination address, and destination port information. The source IP address comprises the IP address C1 of the host 300, and the source port information comprises the port CP1 from which the host 300 connects to the NAPT gateway 310. The destination

30   IP address comprises the public IP address G of NAPT

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gateway 310, and the destination port is the port GP1 of NAPT gateway 310 corresponding to port SP1 of server 320.

Normally, after receiving data packet 330 using transport-and-receiving unit 317, the NAPT gateway 310 searches NAPT translation table 314. If the corresponding translation data is not located in the NAPT translation table, the NAPT gateway 310 searches the virtual server mapping table 312. In this embodiment, data packet 330 is the first packet transported to port GP1 of NAPT gateway 310 by host 300, so virtual server mapping table 312 is searched for the related mapping data of the data packet 330. After searching and determining that the data packet 330 is to be transported to the port SP1 of the internal server the address of which is S1, the processing unit 316 acquires an unused entry of NAPT translation table 314 the index of which is I1 to store NAPT translation data. The NAPT translation data comprises private server IP address S1 and private server port information SP1, gateway IP address G and gateway port information GP1, host IP address C1 and host port information CP1.

Next, the processing unit 316 translates the destination IP address and port information into private IP address S1 and port SP1 of server 320 and source port into a factor J1 related to the index I1 corresponding to the entry recording the translation data. Thus, the data packet 330 is translated into data packet 332. The factor J1 may be the index I1 or

produced by adding index I1 to a constant, where the maximum value of the factor J1 is $2^{16}-1$. Finally, the transport-and-receiving unit 318 of the NAPT gateway 310 transports the data packet 332 to the real

5 destination, i.e. server 320, according to the destination IP address.

In addition, the server 320 can return data packet 334 from port SP1 through NAPT gateway 310 to the host 300. The data packet 334 comprises source IP

10 address, source port information, destination IP address, and destination port information. The source IP address and source port comprise IP address S1 and port SP1 of server 320, and the destination IP address and the destination port comprise IP address C1 of the

15 host 300 and the factor J1 related to the index.

When NAPT gateway 310 receives the returned data packet 334 the factor J1 of which equals the index I1, the factor J1 is directly mapped to the translation data the index of which comprises I1 to perform NAPT.

20 If factor J1 is produced by adding index I1 with a constant, when the index I1 is acquired by a simple operation, the index I1 is directly mapped to a translation data the index of which is I1 in the NAPT translation table 314 to perform NAPT. The

25 translation data is acquired without hashing or linear searching, so time is saved, and the processing speed of the packet is enhanced. After acquiring the translation data, the NAPT gateway 310 performs a comparison to ensure that the acquired translation

30 data is correct.

Next, the processing unit 316 replaces the source
IP address and source port of data packet 334
respectively with G and GP1, comprising the public IP
address of the NAPT gateway 310 and the port of the

5   NAPT gateway 310 corresponding to the port SP1 of
server 320 and the destination port with port CP1 of
the host 300 recorded in the translation data. Thus,
the data packet 334 is translated into data packet
336. Finally, the transport-and-receiving unit 317 of

10   the NAPT gateway 310 transports the data packet 336 to
host 300 according to the destination IP address
therein.

Referring to Fig. 3, the host 302 in the external
network can also transport a first data packet of a

15   data stream from the port CP2 to the port GP2 of NAPT
gateway 310. The first data packet comprises source
IP address, source port information, destination IP
address, and destination port information. After
receiving the data packet, the NAPT gateway 310

20   searches the virtual server mapping table 312
according to the data packet, determining that the
data packet is to be transferred to port SP2 of the
server IP address of which is S2. Because the data
packet is the first packet of the data stream, an

25   unused entry with index I2 of NAPT translation table
314 is located and used to record the translation data
comprising private IP address S2 and port information
SP2 of the server 322, IP address G and port
information GP2 of the gateway 310, and IP address C2

30   and port information CP2 of the host 302.   In

addition, host 304 in the external network can also transport a first data packet of a data stream from the port CP3 to the port GP1 of NAPT gateway 310. The first data packet includes source IP address, source

5 port information, destination IP address, and destination port information. After receiving the data packet, the NAPT gateway 310 searches the virtual server mapping table 312 according to the data packet, determining that the data packet is to be transferred

10 to port SP1 of the server the IP address of which is S1. Because the data packet is the first packet of the data stream, an unused entry with index I3 of NAPT translation table 314 is located and used to record the translation data including private IP address S1

15 and port information SP1 of the server 320, IP address G and port information GP1 of the gateway 310, and the IP address C3 and port information CP3 of the host 304. Next, the translation of the data packet, similar to that mentioned above, includes not only

20 translating the destination IP address and destination port but also translating source port into a factor related to an index. Thus, when receiving the outgoing data packet from the internal (virtual) network, the NAPT gateway 310 of the invention can

25 acquire the translation data by direct mapping and transport the outgoing data packet to external hosts 302 or 304.

In addition, when subsequent data packets of the same data flow are transported from the external

30 network to the internal network, due to the

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translation data being recorded in the NAPT
translation table 314, the NAPT gateway 310 of the
invention searches the corresponding index using
hashing, as with a general NAPT gateway. Next, the
5   translation of the data packet, similar to the first
data packet, comprises not only translating the
destination IP address and destination port but also
translating a source port into a factor related to an
index. Thus, when receiving the returned packets from
10   internal network to external network, the NAPT gateway
310 of the invention acquires the corresponding
translation data of the returned data packets by
direct mapping, translating and transporting the
returned data packets.

15   Fig. 5 is a structural diagram of the network
address port translation (NAPT) gateway of the second
embodiment of the invention. Fig. 5 is similar to
Fig. 3 and is further characterized by the processing
unit 516 which controls the network address and port
20   look-up and translation using a different method. It
should be noted that the elements in Fig.3 and Fig. 5
performing the same functions are labeled with the
same number.

         Fig. 6 shows a schematic diagram of the method of
25   fast look up and translation of network address and
port in the second embodiment of the invention. The
host 300 in the external network transports a data
packet 330 from port CP1 to port GP1 of NAPT gateway
510. The data packet 330 comprises source IP address,
30   source port information, destination address, and

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destination port information. The source IP address comprises IP address C1 of the host 300, and the source port information comprises port CP1 from which the host 300 connects to the NAPT gateway 510. The

5   destination IP address is public IP address G of NAPT gateway 510, and the destination port is port GP1 of NAPT gateway 510 corresponding to port SP1 of server 320.

       Normally, after receiving data packet 330 using

10 transport-and-receiving unit 317, the NAPT gateway 510 searches NAPT translation table 314. If the corresponding translation data is not located in the NAPT translation table, the NAPT gateway 510 searches the virtual server mapping table 312. In this

15 embodiment, data packet 330 is the first packet transported to port GP1 of NAPT gateway 510 by host 300, so virtual server mapping table 312 is searched for the related mapping data of the data packet 330. After searching and determining that the data packet

20 330 is to be transferred to the port SP1 of the internal server the address of which is S1, the processing unit 516 acquires an unused entry of NAPT translation table 314 the index of which is I1 to store NAPT translation data. The NAPT translation

25 data include private server IP address S1 and private server port information SP1, gateway IP address G and gateway port information GP1, host IP address C1 and host port information CP1.

       Next, the processing unit 516 translates the

30 destination IP address and port information into

private IP address S1 and port SP1 of server 320 and source IP address into a factor J1 related to the index I1 corresponding to the entry recording the translation data. Thus, the data packet 330 is translated into data packet 532. The factor J1 may be produced from index I1 logically operated with [10.0.0.0], wherein maximum value of the factor J1 is $2^{24}-1$. The factor J1 may be produced from index I1 logically operated with [172.16.0.0], wherein maximum value of the factor J1 is $2^{20}-1$. The factor J1 may be produced from index I1 logically operated with [192.168.0.0], wherein maximum value of the factor J1 is $2^{16}-1$. Finally, the transport-and-receiving unit 318 of the NAPT gateway 510 transports the data packet 532 to the real destination, i.e. server 320, according to destination IP address.

In addition, the server 320 can return data packet 534 from port SP1 through NAPT gateway 510 to the host 300. Because direct mapping in the method of the second embodiment depends on IP address, the method works even if the data packet 534 is IP fragmented. The data packet 534 comprising source IP address, source port information, destination IP address, and destination port information. The source IP address and source port comprise IP address S1 and port SP1 of server 320, and the destination IP address and the destination port comprise factor J1 related to the index and the port CP1 of the host 300.

When the index I1 is acquired from the factor J1 by a simple operation, the index I1 is directly mapped

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to a translation data the index of which is I1 in the NAPT translation table 314 to perform NAPT translation. The translation data is acquired without hashing or linear searching, so time is saved, and

5 packet processing speed is enhanced. After acquiring the translation data, the NAPT gateway 510 performs comparison to ensure that the acquired translation data is correct.

Next, the processing unit 516 replaces the source

10 IP address and source port of data packet 534 respectively with G and GP1, comprising the public IP address of the NAPT gateway 510 and the port of the NAPT gateway 510 corresponding to the port SP1 of server 320 and the destination IP address with the IP

15 address C1 of the host 300 recorded in the translation data. Thus, the data packet 534 is translated into data packet 336. Finally, the transport-and-receiving unit 317 of the NAPT gateway 510 transports the data packet 336 to host 300 according to the destination IP

20 address.

Referring to Fig. 5, the host 302 in the external network can also transport a first data packet of a data stream from the port CP2 to the port GP2 of NAPT gateway 510. The first data packet includes source IP

25 address, source port information, destination IP address, and destination port information also. After receiving the data packet, the NAPT gateway 510 searches the virtual server mapping table 312 according to the data packet, determining that the

30 data packet is to be transferred to port SP2 of the

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server the IP address of which is S2. Because the
data packet is the first packet of the data stream, an
unused entry with index I2 of NAPT translation table
314 is located and used to record the translation data
5   including private IP address S2 and port information
SP2 of the server 322, IP address G and port
information GP2 of the gateway 510, and IP address C2
and port information CP2 of the host 302. In
addition, host 304 in the external network can also
10   transport a first data packet of a data stream from
the port CP3 to the port GP1 of NAPT gateway 510. The
first data packet comprises source IP address, source
port information, destination IP address, and
destination port information also. After receiving
15   the data packet, the NAPT gateway 510 searches the
virtual server mapping table 312 according to the data
packet, determining that the data packet is to be
transferred to port SP1 of the server the IP address
of which is S1. Because the data packet is the first
20   packet of the data stream, an unused entry with index
I3 of NAPT translation table 314 is located and used
to record the translation data including private IP
address S1 and port information SP1 of the server 320,
IP address G and port information GP1 of the gateway
25   510, and IP address C3 and port information CP3 of the
host 304. Next, the translation of the data packet,
similar to that mentioned above, not only translates
the destination IP address and destination port but
also source address into a factor related to an index.
30   Thus, when receiving the outgoing data packet from the

internal (virtual) network, the NAPT gateway 510 of the invention acquires the translation data by direct mapping and transports the outgoing data packet to external hosts 302 or 304.

5   In addition, when subsequent data packets of the same data stream are transported from the external network to the internal network, due to the translation data being recorded in the NAPT translation table 314, the NAPT gateway 510 of the

10   invention searches the corresponding index using hashing, as with general NAPT gateways. Next, the translation of the data packet, similar to the first data packet, includes not only translating the destination IP address and destination port but also

15   translating source address into a factor related to an index. Thus, when receiving the returned packets, by IP fragmented or not, from internal network to external network, the NAPT gateway 510 of the invention can acquire the corresponding translation

20   data of the returned data packets by direct mapping, then translates and transports the returned data packets.

It should be noted that, in this embodiment, the NAPT gateways without load balance function are used

25   as examples, although the method of network address fast look-up and translation of network address and port of the invention can also be implemented in a load balancing NAPT gateway.

To sum up, the method of network address port

30   translation and fast look-up of the invention can be

performed in a NAPT gateway. When the data packets are transported from an internal server to a NAPT gateway, the indices drawn from destination IP addresses or destination ports can be directly mapped

5   to the translation data in the NAPT translation table without hashing or linear searching. Thus, the method of network address port translation and fast look-up of the invention enhances packet processing speed.

While the invention has been described by way of

10   example and in terms of the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. To the contrary, it is intended to cover various modifications and similar arrangements (as would be apparent to those skilled in

15   the art). Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.